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Executive Development

Preventive Maintenance: A Proactive Approach to Apparatus Readiness and Safety

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August 2008

Appendices Not Included. Please visit the Learning Resource Center on the Web at <http://www.lrc.dhs.gov/> to learn how to obtain this report in its entirety through Interlibrary Loan.

EXECUTIVE FIRE OFFICER PROGRAM--APPENDIX

CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: 

ABSTRACT

The problem is the Waterbury Fire Department (WFD) lacks a comprehensive preventive maintenance (PM) program for fire apparatus, which may result in the increased out of service time, decreased readiness of the fleet, and poses the possibility of unsafe apparatus responding to calls. The purpose of this research was to develop the criteria for a PM program to effectively decrease out of service time and ensure the safety of the fire service apparatus within the WFD fleet. To address the problem, the attempt to answer the following questions occurred: what is the standard for PM on fire service apparatus, what is the impact of PM on fire service apparatus out of service time, what impact does PM have on fire service apparatus safety, what are the qualifications required to perform PM on fire service apparatus, and finally, what criteria is necessary for an effective PM program? By employing a descriptive research methodology, these questions were answered to provide a paradigm of preventive maintenance for the WFD. A survey was conducted to evaluate the make-up of area department's maintenance and fleet, attitude towards preventive maintenance, and the value placed on preventive maintenance. Two face-to-face interviews were conducted to explore what occurs in private industry and within a private apparatus service company, and a comprehensive literature review was conducted to explore the various avenues of preventive maintenance programs. The results of the research and data gathering confirmed the importance and value of preventive maintenance. Recommendations included, but not limited to, the development of a preventive maintenance program and schedule, increased certification levels for staff mechanics,

adherence to Federal regulations and recommendations, and developing a field maintenance program.

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INTRODUCTION

Apparatus represents the single costliest purchase the fire service incurs on a semi-regular basis. The proper specifying and procurement is critical to the longevity of the apparatus that serves a community for upwards of twenty-five years. Proper care and maintenance ensures the long life of that equipment and apparatus, which also serves to keep the cost to the department lower. The ability for a department to hold costs down in the volatile present day economy will provide municipalities the added resources they require in a timely fashion.

The problem is the Waterbury Fire Department (WFD) lacks a comprehensive preventive maintenance (PM) program for fire apparatus, which may result in the increased out of service time, decreased readiness of the fleet, and poses the possibility of unsafe apparatus responding to calls for service. PM is the act or work of keeping something in proper condition by performing necessary preventive actions in a routine manner to prevent failure or breakdown (National Fire Protection Association [NFPA], 2007).

The purpose of this research is to develop the criteria for a PM program to effectively decrease out of service time and ensure the safety of the fire service apparatus within the WFD fleet.

To address the problem stated earlier, the following questions require answering; what is the standard for PM on fire service apparatus, what is the impact of PM on fire service apparatus out of service time, what impact does PM have on fire service apparatus safety, what are the qualifications required to perform PM on fire service apparatus, and finally, what criteria is necessary for an effective PM program? By

employing a descriptive research methodology, these questions will be answered by conducting two interviews with an industry expert, one from the fire service and the other from the private sector. In addition, a survey to identify the generally accepted practices of fire departments throughout the region concerning maintenance of apparatus in general, and PM specifically was conducted. Information was gathered and collated to provide an in depth view of PM and how it is conducted throughout the region.

BACKGROUND AND SIGNIFICANCE

The City of Waterbury Connecticut has a population of 107,271 (United States Census Bureau, 2000) which is served by the 244 personnel of the Waterbury Fire Department. The department responds to calls for service with nine engine companies, three truck companies, and a heavy rescue/hazmat company. The total number of vehicles and apparatus within the department is 52, all of which require maintenance. In 2007, the department responded to 5328 (City of Waterbury Fire Department, 2008, p. 2) calls for service. That number, coupled with the geographical layout of the city of steep hills and short streets, results in an above average amount of maintenance to critical apparatus components. Protecting the viability of the \$12.8 million (City of Waterbury Fire Department, 2008, p.3) investment in apparatus is paramount to an effective PM program and ensuring a long and productive service life.

May 10, 1990, while responding to an automatic alarm at a local high school, WFD's Engine 11 responded as per standard operating procedures, which included lights and siren. The engine had to travel down a street that concluded with a steep decline of approximately thirty degrees. Approximately halfway down that hill, the

apparatus chauffer applied the brakes to no avail. The resultant crash into a tree caused the deaths of two firefighters and severely injured the officer. The Connecticut Department of Motor Vehicles (CDMV) and the National Transportation Safety Board (NTSB) conducted the investigation and found that three of the four rear brake shoes were not making any contact with the brake drum. Subsequent inspections revealed 64% of the apparatus failed inspection and required being placed out of service until repairs were made (National Transportation Safety Board, 1991, p. 2). As a result, the department embarked on brake safety inspections and a brake test procedure completed before the start of the oncoming shift. Connecticut does not mandate the periodic inspection of fire apparatus by the CDMV, but will inspect apparatus on a voluntary basis if the department requests it.

The department failed to institute broad-based changes in the maintenance division in light of the accident and recommendations by CDMV and the NTSB. Record keeping was still pen and paper driven; repair requests were lost, not reported, or ignored. Brake issues still arose, yet nothing definitive was done to rectify the situation, to the point, that even post-May 1990, brake issues, if identified by the chauffer, the master mechanic would have the company drive the apparatus to the maintenance facility. There was the lack of certified mechanics, a lack of a defined plan of maintenance, and a complete lack of PM.

On May 19, 2007, another fatal accident involving fire apparatus occurred in Waterbury, claiming the life of one captain and severely injuring the driver. Four other firefighters sustained moderate to minor injuries because of the crash. The ensuing investigation conducted by the Waterbury Police Department (WPD) and the

Connecticut State Police (CSP) concluded that driver error was the single cause of this accident. Contained within the report though, was an observation by the CSP that the right rear brakes were “out of adjustment”. Because of this and other findings, the CSP requested the maintenance records for the apparatus involved in the accident. Again, as in 1990, record keeping and accounting of service records was abysmal. There was a complete lack of adequate inspections and service conducted on the apparatus, which lead investigators to report that this was indicative to the bureau (Corbett, Gavaletz, Hanson, & Keroack, 2007, pp. 47-48). Due to the seriousness of the report, the WFD began conducting an internal investigation into the record keeping and maintenance records of the fleet. It was found that daily inspection sheets were scattered about the repair facility in unlabeled boxes, in piles of nondescript papers, and elsewhere, other than in the respective apparatus files. Aerial inspection and certification paperwork could not be found, there was no record of parts and services conducted that could be deemed reliable, in fact the bureau was completely unorganized. The lack of a comprehensive maintenance schedule, accurate records, and the ability to computerize and track repairs made the transfer of a Battalion Chief into the bureau a necessity for the reduction of liability to the city, to increase the safety to the firefighters and public.

The purpose of this research, in satisfying the National Fire Academy's Executive Development (ED) requirements, is to improve the service quality within the fire service. Service quality will increase due to the proper care and maintenance of the apparatus within a department's fleet. Quality of service delivery will maintain at an elevated level, or increase, so long as equipment is in proper working order, thus, service to the customer is enhanced. Performance, reliability, and serviceability are

critical to the mission statement of the organization, and are crucial to the fire service as a whole. Change, and change management are also issues within the curriculum of the ED program that are addressed in this research. Currently the WFD lacks an effective means of tracking repairs, conducting inspections and tests on a regular basis, and accounting for out of service time of front line apparatus. An entirely new way of conducting daily, weekly, and monthly operations requires changing, and the leaders of the department need to understand and become the change-agents for that adaptation (2006, National Fire Academy, Homeland Security) .

In complying with the United States Fire Administration's (USFA) Operational Objectives, the issue of firefighter safety is paramount and a preventive maintenance program should serve as a paradigm for satisfying that objective. Guarantying safe apparatus will allow for again, better service delivery, but also, ensure the safety of the firefighters staffing the apparatus and the public.

Once again, the total lack of records, activity reports, maintenance schedules, certified mechanics, and a plan, was brought to light after this accident. The statutory requirements for the department to adhere to were never met, let alone followed. As a result, sweeping changes became necessary to fulfill these various and numerous responsibilities.

LITERATURE REVIEW

The National Fire Protection Association (NFPA), although not codified, does satisfy the "reasonably prudent person" criteria when presented in a court of law.

Individual action or failure to act as a reasonably prudent person would under similar circumstances, resulting in harm to another, also called

negligence. A reasonably prudent person is defined by the standards of the profession that are followed, and the level of expertise expected of a person with like training (Baron's Educational Series 2000, p 1).

The reality is, the NFPA Standards regarding apparatus inspection, maintenance, specifications, testing, and qualifications are accepted "industry standards", therefore would be upheld in a court of law whenever they were cited (2005, *Fire Chief*). The important aspect to be mindful of is that this standard will be used in a court of law should the need ever present itself. The standard has stood the test of time and the challenges of the court system. This is the accepted standard throughout the fire service, nationally and internationally.

There are numerous components pertaining to PM within the NFPA, and each merit examination in detail. NFPA 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus governs the recommended maintenance intervals and components of the inspection and service duties of the Authority Having Jurisdiction (AHJ) which the organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure (National Fire Protection Association [NFPA], 2007).

. This standard is a combination of NFPA 1911, Standard for Service tests of Fire Service Pumps on Fire Apparatus, NFPA 1914, and Standard for testing Aerial Apparatus, and NFPA 1915, Standard for Fire Apparatus Preventative Maintenance Program. The history of the standard, specifically 1915, has its roots in the 1990 accident in Waterbury and is documented in the NTSB report "Special Investigation

Report-Emergency Fire Apparatus” (NFPA 1911 2006) This standard also includes the out of service criteria necessary to ensure the safety of apparatus and firefighters riding on them. The AHJ is not required, by law, to follow the standard’s recommendations, but a comparison of 1911 and Title 49 Section 399 of the Federal Code of Regulations, indicates the two are closely related and contain much of the same language. The NFPA also generally recognizes and adopts Federal and State regulations with the idea that the statute will meet or exceed the standard.

A comprehensive examination of 1911 illustrates the totality of this standard in the recommended practices required of maintenance facilities. Chapter 4.5.1 ensures that all federal, state, and local statutes are complied with in the maintenance and inspection of the AHJ apparatus. Inspections are defined as, to determine the condition or operation of a component(s) by comparing its physical, mechanical, and/or electrical characteristics with established standards, recommendations, and requirements through examination by sight, sound, or feel (National Fire Protection Association [NFPA], 2007). Chapter 4 also addresses the implementation of a maintenance schedule, daily or weekly inspections and the documentation involved in these inspections. Maintenance is defined as, the act of servicing a fire apparatus or a component in order to keep the vehicle and its components in proper operating condition (National Fire Protection Association [NFPA], 2007).

Documentation of inspections, repairs, and diagnostics is imperative to comply with this standard. Annex C of 1911 covers the necessary criteria to be included in the inspection forms needed to conduct said daily/weekly inspections. This annex, “while not a part of the requirements of this NFPA standard, it is included for informational

purposes only” (National Fire Protection Association[NFPA], 2006, p. C.1.). Having the tools necessary to establish a PM program is crucial to the success of the program, and NFPA 1911, and especially Annex C will ensure that success if followed.

The Standard also details the out-of-service criteria, the condition when an apparatus or component is not usable due to an unsafe or inoperable condition (National Fire Protection Association [NFPA], 2007), that departments need to be mindful of which are discussed in detail in Chapter 6. These criteria are vital to the safety of apparatus and the personnel riding on them. The public’s safety is often times overlooked in the fire service’s zeal to provide service, but that is also a factor included in the analysis of the criteria. NFPA 1911 gives the operator the authority to place apparatus out-of-service should it meet any of the criteria identified in Chapter 6. The criterion put forth is a systematic approach in the inspection process identifying the potential failure or failed component or system on the apparatus on a component-by-component basis. In conjunction with this Standard, one regulation, which does have the force of law, is Title 49 of the Code of Federal Regulations (CFR). Part 396 of Title 49 details the procedures for the inspection of commercial vehicles that closely mirrors NFPA 1911, giving departments the backing of Federal law to ensure the safety of apparatus and personnel. Title 49 also contains Appendix G that details the inspection and out-of-service criteria set forth by the United States Department of Transportation. While not mandated, Title 49 passes the “reasonably prudent person” criteria if a department adopts the regulations as their own. The one factor that poses a problem to the fire service in the Code is Part 390.3 Para f no. 5, exemptions. It states, “The operation of fire trucks and rescue vehicles while involved in emergency and related

operations” (Federal Motor Carrier Safety Administration, 2007, p. 247). This exemption muddies the water in the State of Connecticut. On one hand, the State has adopted in law, Title 49 Parts 396.17, 396.19, 396.21, and 396.25, which standardizes the inspection criteria statewide. It fails to address the out-of-service criteria, and the lack of standardization within the state motor vehicle laws (Commission on Fire Prevention and Control, 2007, p. 1).

NFPA 1500 Standard on Fire Department Occupational Safety and Health Program 2007 Edition Chapter 6.4 discusses the periodic inspection and maintenance of apparatus. This vital Standard, as a whole, adopted or followed by every department across the country, gives little attention to the vital and essential subject of apparatus inspection and maintenance and the associated safety factors inherent to a comprehensive PM program (National Fire Protection Association[NFPA], 2006).

NFPA 1071 details the requirements for the qualifications of *Emergency Vehicle Technician* (EVT). This Standard specifies the educational and technical expertise required to perform repairs and inspections on fire apparatus. In conjunction with the National Institute of Automotive Service Excellence (ASE) and the Emergency Vehicle Technician Certification Commission, the NFPA has developed the minimum qualifications for personnel to earn the EVT certification. Any mechanic certified to the level of EVT Level1 has the *requisite knowledge* required by the Standard to conduct inspection, maintenance, and the repairs on fire apparatus (National Fire Protection Association [NFPA], 2006). The AHJ has final say in the establishment of minimum standards the mechanics possess that service the department’s apparatus, either in-house or through an outside vendor. NFPA 1071 is only a minimum standard, meaning,

the AHJ may *exceed* this standard (National Fire Protection Association [NFPA], 2007). The comprehensive nature of the standard, as well as the technical idiosyncrasies of apparatus, require a municipality to carefully weigh the risk-benefit if they so choose to ignore this standard and employ standards less rigid than NFPA 1071, they need to recognize the inherent risks associated with that decision (Steffens, 2000).

An inspection begins at shift change, or whenever drivers switch out. To say the only inspections that the department conducts are on a monthly, hourly, or mileage-based system is false. The Federal Motor Carrier Safety Administration (FMCSA) requires that these daily inspections, conducted in a *post* trip inspection when dealing with the commercial trucking industry. While there is no hard and fast regulation governing fire apparatus, a *pre*-trip inspection is the more prudent approach to this issue. A driver reporting for duty will receive a verbal account of apparatus activity and any problems encountered. It is incumbent upon the incoming driver to thoroughly inspect and test the apparatus to ensure the safety of the personnel and the public. This all-encompassing check is necessary to guarantee the apparatus is available to respond effectively. Documentation of problems identified during the inspection is the first step in the PM process. If the issue is determined to be an out-of-service criterion, then that apparatus cannot respond or move until a mechanic has either cleared it for safe travel or determined the need for other means of removal for repair. This initial step, so vital to a progressive and comprehensive preventive maintenance program, is often overlooked, or dismissed as being a trivial nuisance.

Private sector trucking firms believe and invest in PM programs as a means of cutting costs and keeping safe vehicles on the road. Dunbar Armored Car Service is

one corporation that takes an aggressive stance on PM. Due to the important cargo and personnel, reliability and safety are key factors the company Director of Fleet Maintenance Douglas White takes extremely seriously. Maintaining the availability of useable vehicles is paramount for the operation to maintain a consistent level of excellence. The program employed by Dunbar has a 97-point checklist the vehicles must endure at every 5,000-mile interval. The technicians on staff are responsible for the complete and detailed inspections and repairs to the fleet. By signing the PM sheet, the mechanic has verified the inspection and repairs have been completed. The safety and confidence of the driver and passenger rely on that testimony (Brothers, 2008, p. 1).

Productivity and profitability also affect and factor in as a major role in the adoption of a PM program. Lowering operating costs, thus, influencing the “bottom line” of private industry, dictates PM makes sense. As operating costs increase (cost per mile), productivity decreases. PM is a proactive approach by Tango Transport from Shreveport Louisiana that actually reduces costs, increases safety and extends the life cycle of their fleet. Redirecting the technicians on staff to train in PM rather than systems or components, in what is called “asset utilization”, has allowed the company to realize real cost savings, and according to Darry Stuart of DWS Fleet Management Services, “understanding PM is the most critical part of ensuring uptime” (Skydel, 2008, p 2). Incorporating a PM check sheet with greater attention to detail also assists in the organized method of conducting inspections, thus reducing the time and cost associated with these inspections. Because of these changes and modifications, Tango

has realized a 2.5-cent drop in cost per mile, and “fewer road calls, less downtime, and higher vehicle utilization rates” (Skydel, p. 3).

According to the Federal Energy Management Program, nearly 50% of all companies in the United States employ a “reactive” maintenance program for their vehicles and equipment. This system addresses problems as they arise rather than taking a proactive or preventive approach to vehicle maintenance. The cost savings associated with the reactive methodology are greater in the short term, yet these savings disappear as time and service life is extended. Affording a PM program is often questioned at the outset, due to the increased expense of diagnostic tools, training, and equipment, but the savings in downtime and increase in customer satisfaction outweigh these apprehensions. Another approach to PM is “predictive” maintenance, which bases services on not only scheduled maintenance intervals, but also “wear indicators” which predict potential catastrophic failures of equipment. The cost savings of predictive maintenance ranges from “8%-12% above using PM alone” (Fleet Maintenance Magazine, 2007).

Another issue to consider when deciding whether a PM program would be cost effective or not is the number of times a piece of equipment requires service between regularly scheduled PMs. Tracking these numbers will give an accurate accounting of the efficiency of the program. The fewer the unscheduled visits, the more effective and efficient the PM program, which directly affects down time and cost. Dividing the program based on vehicle type, type of usage, and frequency of usage is important, since no two vehicles are the same. A specific PM schedule for engines and aials would be justified, as would a separate PM schedule for staff vehicles. Accurate records

of repetitive maintenance or “trouble” components is also critical to record keeping in order to forecast future repairs, or target defective components for replacement (Public Works Staff, 2006).

The point of a PM program is *preventive maintenance*, that is to say, preventing problems and having adequate maintenance to keep apparatus or commercial vehicles in service. While the fire service is not a “for profit” organization, down time increases the chance of front line apparatus not being available to respond. As a taxpayer, the citizens would demand that their investment is protected and cared for to extend that the service life and serviceability increases in order to get a better return on their investment. The fiscal aspect of PM and the savings it provides is evident in the increase in service life and decrease in equipment failure. The other “Long-term benefits of preventive maintenance include: ...system reliability, decreased cost of replacement ...downtime, and better inventory management” (ReliaSoft Corporation, 1999-2007 p. 1).

While conducting the research and subsequent literature review, sources within the private sector and commercial trucking industry proved invaluable to addressing the critical nature of PM and the requirements to conduct and track an effective program. Every source that was researched gave corroborating testimony as to the cost-savings, time savings and safety enhancement that PM affords a department or company. Increasing the service life of vehicles, apparatus or commercial trucks, was another benefit of conducting PM on a regular, scheduled timetable. The prevention aspect of PM reduced downtime significantly according to the commercial sources, and increased productivity. The criterion involved in establishing a PM program is more stringent in the

fire service due to the emergency and critical nature of the service, yet the components were comparable to the commercial industry standards. Adhering to the NFPA Standards offers municipalities another layer of protection from the liability of haphazard and chaotic maintenance. A systematic approach to PM alleviates this issue.

Having a PM program in place has been proven to reduce downtime and allow the front line apparatus to remain in service, reducing costs, lost man-hours, and increasing the safety of personnel operating the apparatus, as well as the public.

PROCEDURE

Descriptive research was the primary research methodology for this paper. The reason for the application of this methodology is to gain a comprehensive understanding of the requirements for, as well as, the parameters involved in conducting PMs, and the certification and training requirements for personnel conducting PM. Recommendations to the department administration, included at the conclusion of this paper, address the formulation and implementation of a PM program to successfully address the failings of the present system.

A search conducted at the National Fire Academy's (NFA) Learning Resource Center while in attendance of the Executive Development Program revealed numerous sources of information. By employing the card catalogue and search engine www.google.com, a list of resources was generated to assist in the writing of this paper. Unfortunately, many of the sources were beyond the five-year criterion established for *timely* research, but a sufficient number of recent, relevant, and timely sources were discovered. By searching *maintenance*, *apparatus*, and *fleet maintenance*, the sources used and cited were found. Extensive research into the NFPA 1071, 1901, and 1911

Standards also provided the necessary basis for answering a number of the research questions. The expansive nature of the Standards provided information necessary to establish a PM program and the various requirements of such a program. A review of current practices, actions, and documentation currently used by the WFD's apparatus maintenance division was conducted to capture the true capabilities and practices in place. A subsequent comparison between these practices and the requirements contained within Title 49 CFR sect. 399 and the recommended practices in NFPA 1911 Annex C was also conducted.

A survey was conducted using www.surveymonkey.com as administrator of the survey. Fifty-five surveys were hyperlinked via email to fire departments within the State of Connecticut, along with members attending the EFO program of March 3-14, 2008. Forty-seven responses were received, translating to an 85.5% return rate. The completed survey and responses is included in Appendix A. The survey asked questions ranging from apparatus fleet size, to number of mechanics, to opinions on the value of PM.

Two face-to-face interviews were conducted at the Apparatus Maintenance and Service facility in Waterbury. The first interview was conducted with Mr. Steven Norbeck, District One Safety and Prevention Manager for Roadway Freight. The purpose of interviewing this subject was to gain the perspective from a large (23,000+ vehicle) corporate fleet, and their attitude towards PM and safety. The second interview was conducted with Mr. Craig Palmer, owner and president of Gowans and Knight, a custom apparatus builder and service center, servicing approximately 250 apparatus in fiscal year 2008, located in Watertown Connecticut. The purpose of this interview was to

gain insight into the safeguards incorporated and required by the NFPA and the value of PM in an emergency agency. A copy of the questions and summary answers are located in Appendix B.

Limitations

By using the LRC as an initial resource, access is only available to those enrolled at the NFA. The library material used consisted primarily of fire service trade journals, which are limited in scope and purpose. The material accessed also was dated to a degree, thus, its use was invalid for evaluating and assessing the current trends in the fire service. The select corporate periodicals cited in this paper were available through the service division maintaining the fleet of WFD apparatus.

The survey that was conducted contained two open-ended questions, that if not answered by the person responsible for the actual maintenance, then the answers had the possibility of being either bias, or incomplete. The survey should have included criteria to identify the person answering the survey and their credentials.

Results

In the process of this descriptive research of the PM problem facing the WFD, the researcher compiled data from a survey conducted to glean information as to the effectiveness and feasibility of initiating a PM program. Through a search of literature and trade publications, information was obtained espousing the virtues, effectiveness, and savings of a PM program. The researcher has developed, because of this research, one, a working knowledge of PM and requirements, and two, the framework for a PM program for the WFD.

The following research questions initially posed were answered as a result of this research.

What is the standard for PM on fire service apparatus?

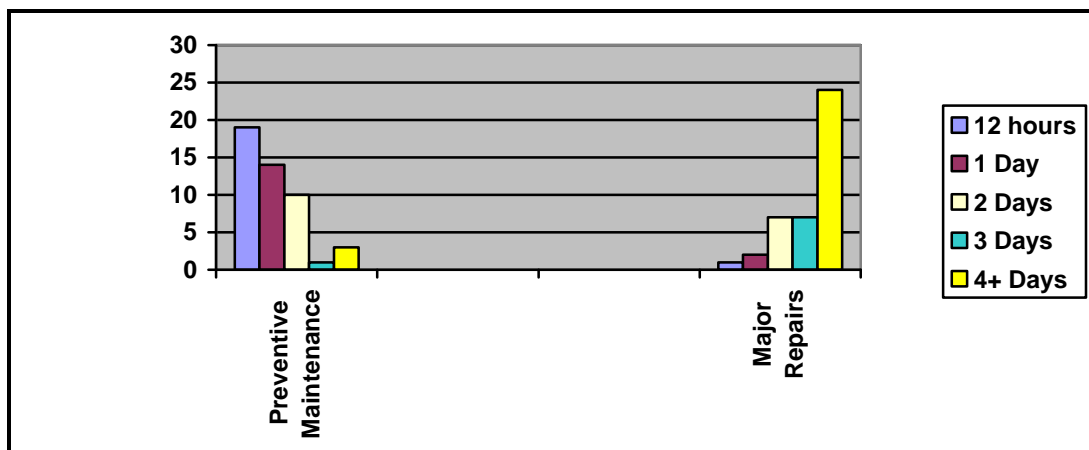
While the NFPA Standards are *recommendations*, Annex C of 1911 contains the recommended components of a fire service PM program for apparatus. This standard addresses all aspects of inspection and maintenance of fire apparatus, including the out-of-service criteria used to ensure the safe operation and protection of firefighters and the public. Commercial applications were investigated and the criteria established, and codified by the Federal government play a major role in the planning and development of a PM for the fire service. By melding the NFPA recommendations and Title 49 CFR together, a comprehensive PM program can be established. This satisfies the statutory and regulatory requirements of Connecticut Department of Motor Vehicles (CDMV) and the Department of Transportation (DOT). Despite the exemption contained within Title 49 Sect. 390 Part 390.3 Para f no. 5 pertaining to fire service apparatus, the fire service would be prudent to adopt these regulations to satisfy the “reasonably prudent person” doctrine.

What is the impact of PM on fire service apparatus out-of-service time?

A direct correlation between out-of-service time and PM was discovered through the two interviews conducted and commercial trade literature and. Craig Palmer stated that PM reduces the chances of catastrophic equipment failure and component failure due to the PM program at his service center. By having “eyes on the parts” and inspecting the numerous components and repairing items as warranted, there is less time required to make the repairs and get the apparatus back in service (C. Palmer,

personal communication, June 2, 2008). Steve Norbeck from Roadway Freight states that keeping trucks on the road and making money makes PM a worthwhile investment in mechanics and equipment. By conducting periodic inspections, problems are kept at a manageable level, thus preventing extended periods of tractors being out-of-service (S. Norbeck, personal communication, April 25, 2008).

Question number 10 in the survey conducted addressed the out-of-service or down time for apparatus in the departments surveyed, the following illustrates graphically, the time spent out of service:



As a result of PM, the out-of-service time is inversely related to repairs conducted. Major repairs take three times the amount of time as preventive maintenance, thus reducing the out-of-service time by 72%. These figures also reflect the answer to question nine, "Does your department have a Preventive Maintenance program"? Forty-seven of forty-seven respondents answered in the affirmative, thus all departments surveyed partake in a PM program.

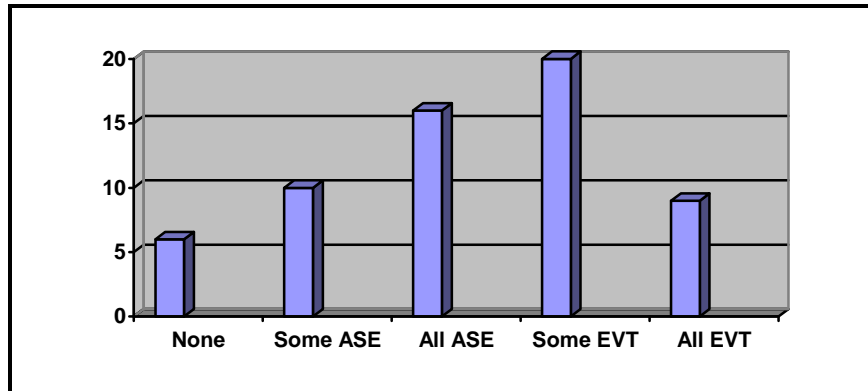
What impact does PM have on fire service apparatus safety?

According to Palmer, again in the face-to-face interview, stated that PM effects safety “1000%” (C. Palmer, 2008). Dunbar Armored Car Service takes an extremely hard stand on PM and ensuring completion of accurate, timely, and comprehensive inspections. In discussions with Palmer and Norbeck, safety is the key factor in conducting PM. The cost benefits are an “added bonus” according the Norbeck. “Knowing the safety of the public and drivers is confirmed by the PM program which allows me to sleep at night”, states Norbeck (S. Norbeck, 2008). In addition to PM, field maintenance (FM) assists in the identification of problems and allows the mechanics the ability to diagnose problems sooner than at a regular service interval. By conducting these impromptu inspections while performing field service, such as greasing the chassis, fixing light bulbs, or checking the suspension, the overall safety of, the apparatus is checked. In the survey when asked if field maintenance was conducted, 61.7% responded yes, and 38.3% responded no. Of those surveyed, the questioned was asked if FM enhances the readiness of apparatus, 70.2% responded yes, with 33 respondents expounding upon their answers. The overwhelming affirmative answers indicates FM is a benefit to the readiness and the safety of the apparatus, which also prevents smaller problems.

What are the qualifications required to perform PM on fire service?

The NFPA clearly recommends the certification of mechanics to EVT Level 1 as a minimum standard for departments to abide by. With the complexity of today's fire apparatus, having certified technicians inspecting and maintaining the apparatus is paramount to the continued upkeep and safety of apparatus. Of the forty-seven respondents to the survey, 9, or 19.1% maintain all EVT certified mechanics. 34%

maintain all Automotive Service Excellence (ASE) certification. The graph below illustrates the diverse certification levels within the area, and the commitment to excellence 61% of the respondents have:



This illustrates the trend of departments having the recommended certified mechanics, or at least working towards that end of EVT certification. The FMSCA requires two years experience to inspect and maintain trucks, with no mention of fire apparatus. The NFPA appears to be the only standard available that enumerates specific requirements, or recommendations for certification.

What criteria is necessary for an effective PM program?

Following the recommendations contained within NFPA 1911, coupled with Title 49 CFR sect. 399, provides for a complete and comprehensive PM program. Completeness is the key when providing this service to the department. If certain checks are left undone or are overlooked, serious safety issues may arise, placing firefighters and the public at risk. Establishing a formalized schedule and adhering to that schedule will enable the department to satisfy all components of the NFPA recommendations and the requirements set forth by the FMCSA.

Discussion

The results of the comprehensive literature review indicate the vast acceptance and implementation of PM within both the private sector and some fire departments. The cost savings and loss of time-savings alone, make the institution of a PM program feasible, prudent, and practical. The safety aspect of PM cannot be denied, Dunbar Armored Car Service relies on PM to ensure the safety of their personnel and customer belongings. PM is an effective means to guarantee that safety of the equipment. Preventing downtime, due to the “specialized nature of the vehicles”(Brothers, 2008, p. 1) is paramount to the continued success of the corporation. The same holds true in the fire service, increased downtime indicates poor maintenance and a disregard for the customers the department serves. The issue of safety of the apparatus was first and foremost in minds of the interviewees when answering questions pertaining to the increased safety as a direct result of PM (C. Palmer, 2008)(S. Norbeck, 2008). The death of a firefighter in Kansas City Missouri in 2005 was directly attributed to the lack of proper maintenance of the fire apparatus. The lack of reserve apparatus caused the deferment of inspections and service recommended by the NFPA and the apparatus manufacturer (2005). Question twenty in the survey conducted asked if PM increased the readiness of the apparatus within the department and 70.2% answered yes. Of the forty-seven responses, thirty-three expounded upon their answer. 76% (25 of 33) felt there was a benefit to decreased downtime and an increase in apparatus safety as a result of PM and FM.

Certification of mechanics is also an important component of any successful PM program. Craig Palmer indicated all of his mechanics were either ASE Master Truck

technicians, or EVT level 1 to Master EVT technician. In the survey, 42.6% of respondents indicated some EVT certified mechanics and 34% indicated all ASE certified mechanics. At the time of this writing, not one WFD mechanic is ASE or EVT certified.

The survey asked the question referring to the assignment of mechanics, that is to say, are they employees of the fire department/municipality, or is the servicing of apparatus outsourced? 51.1% indicated the work was outsourced to non-departmental facilities. On the other hand, 61.7% indicated the municipality did the work. This illustrates some confusion as to the intent of the question, or more than likely, some repair work is out sourced and some work is completed in house.

The overall concept of PM is widely accepted and encouraged within the private sector, as noted in the interview and publications. The survey also had indications of the larger departments conducting PM within their facilities based upon size of their fleet, >20 (19.1%) and size of maintenance budget \$200,000-<\$300,000 (23.3%). Of these departments, 19.1% had 4-7 mechanics on duty to affect repairs and perform service. That investment in time, money, personnel indicates a commitment by the individual departments to maintain their fleet at optimum readiness and efficiency. The WFD's budget currently for FY09 is \$210,000 with a staff of three mechanics and a Battalion Chief in administrative control of the Division. 80.9% of departments surveyed indicated they had a staff of between one and three mechanics on staff, which firmly places the WFD within those parameters.

The results of the research conducted is multifaceted. It is imperative from a legal standpoint to implement a comprehensive program that uses the NFPA and FMCSA PM

and inspection criteria as a base for the fire department servicing of apparatus. Providing a comprehensive and complete PM schedule, and adhering to it, will satisfy the guidelines set forth within both the Standard and statute. Having the mechanics on staff pursue ASE Master Truck certification, along with EVT certification is imperative. Having certified mechanics working on apparatus complies with NFPA 1071, but makes sense. Instituting an innovative process and proactive maintenance and PM culture from the mechanics to the operators and officers will ensure safe and operating apparatus.

Recommendations

At the time of this writing, as a result of the extensive research conducted, numerous changes have been initiated in the Maintenance Division in the WFD. The process of a complete implementation program is slow, initially costly, and time consuming. The first issue that required the immediate addressing was a PM schedule. Attached in Appendix C is a copy of the yearly schedule compiled within the past four months to satisfy the recommendations set forth in NFPA 1911 concerning the routine inspection and scheduled maintenance of fire apparatus. There were issues that, through the literature review and other research that brought to light other problems that were linked to the purpose statement and this researcher would be remiss if they were not addressed within these recommendations. Failure to do so would have made this project incomplete, but furthermore, would not have benefited the WFD with a full and comprehensive program upgrade. The recommendations for the WFD are as follows:

1. Adhere to the strict compliance of the scheduled PM and repairs to apparatus. Establishing a comprehensive annual inspection and service

schedule was the first result of this research. The researcher acknowledged the lack of such schedule early on in the ARP process, and addressed that immediately. As a result of the schedule, inspections and maintenance has been reduced from approximately seven business days, to 3 business days, a reduction of 57% in lost or out of service time. There is no way to place a dollar figure on the cost savings or increased protection, but those figures would also be substantial.

2. Create an “Out-of-Service” criteria list for apparatus operators to reference if needed, or there is a question as to the serviceability of the apparatus. This satisfies the DOT requirements and NFPA recommendations. This also directs the Maintenance facility to address these issues immediately to prevent undue down time.
3. Establish the criteria for testing and promoting mechanics within the Bureau of Apparatus Maintenance and Service (BAMS). Institute the certification requirements for all personnel and mechanics who are conducting inspections and repairs on apparatus and other emergency vehicles in the department. This addition will satisfy NFPA 1071, *Standard for Emergency Vehicle Technician Professional Qualifications*. By utilizing this standard and making it an integral part of a Maintenance facility, trust and confidence is built between the personnel operating the equipment and the mechanics working on the equipment.
4. Establish a timetable for the certification of mechanics, first to ASE Master Truck Technician, and then initiate the certification process for EVT Level

1 technician. The goal ultimately, is to have EVT Master Technician certified mechanics on staff, and having the mechanism in place for the training and further education of other personnel to achieve these certifications.

5. The establishment of a “Field Maintenance” (FM) program to address “nuisance” problems, i.e. light bulbs, fuel, greasing, and other problems or issues that do not require the apparatus to leave there “first due” response area will reduce unnecessary wear and tear on the apparatus and wasted time out of district. This will also allow mechanics to visualize the apparatus more frequently than just at scheduled maintenance and inspection times. By having the mechanic under the apparatus and putting “eyes on the parts”, greater vigilance is afforded and the prevention of major problems may be the result.
6. Computerization of records and repairs is necessary for the proper retention and documentation of service inspections, and repairs completed to satisfy DOT and, in the event of an accident, the DMV. Accurate record keeping is critical to the reduction of liability to the Municipality, Apparatus Operator, and mechanics. Included in this recommendation is the safeguarding of the physical check sheets and paper records to the point of an archival system to ensure their retention and safety.
7. Tracking of repairs and out of service time will assist the department in the evaluation of apparatus, equipment, and the maintenance facility. These

databases will allow accurate and educated decisions to be made on costly items such as apparatus and equipment.

8. Institute the cultural change within the department to illustrate the vital importance and link between apparatus readiness and safety with firefighter and public safety.
9. Ensure the commitment of the Department's administration to an apparatus replacement program to reduce costs and ensure the safest possible equipment is provided for the personnel operating them and providing the best protection to the public.

Further recommendations for future readers are as follows to assist other departments in complying with the various requirements and recommendations:

1. Conduct an audit of individual maintenance facilities.
2. Evaluate PM program, or if lacking, conduct research into feasibility for the department to institute one.
3. If maintenance is outsourced, conduct cost comparison between the continued outsourcing, or conducting in-house maintenance.
4. Ensure department is adhering to DOT requirements and NFPA recommendations for apparatus maintenance, inspection, documentation, and repairs.
5. Conduct evaluation of mechanic's level of certification and make certain level is commensurate with work being performed.

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